OFFICIAL

Application No. 09/833,330 Customer No. 01933

Attorney Docket No. 01224/LH

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): Nobuyasu SAKAI

Serial No. : 09/833,330

Filed : April 12, 2001

For : MULTI-FUNCTIONAL VIBRATION ACTUATOR CAPABLE OF SUPPRESSING AN UNSTABLE OPERATION AROUND A RESONANCE FREQUENCY

Art Unit : 2643

Examiner : H. D. Le

CERTIFICATE OF FACSIMILE TRANSMISSION
TO NO. 1-703-872-9306

TOTAL PAGES: 21

I hereby certify that this paper is being facsimile transmitted to the Asst. Commissioner for Patents Office on the date noted below.

Daniel J. Bersohn

Dated: July 30, 2004

In the event that this Paper is late filed, and the necessary petition for extension of time is not filed concurrently herewith, please consider this as a Petition for the requisite extension of time, and to the extent not tendered by form PTO-2038 attached hereto, authorization to charge the extension fee to Account No. 06-1378.

SUBMISSION OF ACCURATE ENGLISH TRANSLATION OF PRIORITY DOCUMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

S I R :

Further to the Response under 37 CFR 1.116 filed July 23, 2004, submitted herewith is an accurate English translation of JP 2000-113312 filed April 14, 2000 whose priority is claimed by the present application.

It is respectfully submitted that the claims of the present application are fully supported by JP 2000-113312 and are therefore entitled to the claimed priority date of April 14, 2000.

Accordingly, as requested in the Response under 37 CFR 1.116 filed July 23, 2004, it is respectfully requested that the rejection in view of EP 1 053 794 to Suzuki be withdrawn.

Authorization is hereby given to charge any necessary fees to deposit Account No. 06-1378.

Application No. 09/833,330 Customer No. 01933

If the Examiner has any comments, questions, objections or recommendations, the Examiner is invited to telephone the undersigned at the telephone number given below for prompt action.

Respectfully submitted,

Douglas Holtz
Reg. No. 33,902

Frishauf, Holtz, Goodman & Chick, P.C.
767 Third Avenue - 25th Floor
New York, New York 10017-2023
Tel. No. (212) 319-4900
Fax No. (212) 319-5101

DH:iv/db
encs.

(Translation)

Name of Document: Patent Application

Reference Number: TK120205

Filing Date: April 14, 2000

To: Commissioner, Patent Office

International Class: H02K 33/18

Inventor:

Address: c/o TOKIN CORPORATION, 7-1, Koriyama 6-chome, Taihaku-ku, Sendai-shi, Miyagi

Name: Nobuyasu Sakai

Inventor:

Address: c/o TOKIN CORPORATION, 7-1, Koriyama 6-chome, Taihaku-ku, Sendai-shi, Miyagi

Name: Fumihiro Suzuki

Applicant:

ID Number: 000134257

Name: TOKIN CORPORATION

Representative: Yuichi Haneta

Tel: 022-308-0011

Official Fee:

Deposit Number: 000848

Sum: 21,000 yen

List of Presented Documents:

Name: Specification 1

Name: Drawing 1

Name: Abstract 1

Proof: Required

(Translation)

[Name of Document] SPECIFICATION

[Title of Invention] MULTI-FUNCTIONAL VIBRATION ACTUATOR

[Claim for Patent]

[Claim 1] A multi-functional vibration actuator including a magnetic circuit, a coil arranged in a gap of said magnetic circuit, and a suspension comprising an arc-shaped helical leaf spring fixed to a vibration transmitting portion and flexibly supporting said magnetic circuit, wherein said vibration transmitting portion is provided with a cover fixed thereto and having a sound release hole of a desired diameter for air viscosity attenuation.

[Claim 2] A multi-functional vibration actuator as claimed in claim 1, wherein said sound release hole is formed as a single hole or a plurality of holes located at desired position or positions of said cover.

[Claim 3] A multi-functional vibration actuator as claimed in claim 1 or 2, wherein said sound release hole has a shape of a circle, an ellipse, an elongated circle, a polygon, or a combination thereof.

[Claim 4] A multi-functional vibration actuator as claimed in any one of claims 1 to 3, wherein said coil is fixedly attached to an L-shaped or a U-shaped attaching portion formed at a desired position of said vibrator member in a radial direction.

[Claim 5] A multi-functional vibration actuator as claimed in any one of claims 1 to 4, wherein said vibrator member has a flat shape, a saucer shape, a curved shape, a corrugated shape, or a combination thereof.

[Claim 6] A multi-functional vibration actuator as claimed in any one of claims 1 to 5, wherein said vibrator member is made of at least one kind of plastic film material selected from polyether imide, polyester, polycarbonate, polyphenylenesulfide, polyarylate, polyimide, and aramide.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

This invention relates to a multi-functional vibration actuator mounted in a mobile communication apparatus, such as a mobile telephone, and having a function of generating a ringing tone, a speech sound, and a vibration.

[0002]

[Prior Art]

Fig. 6 shows a conventional multi-functional vibration actuator. Fig. 6(a) is a sectional view taken along a line B-B in a plan view illustrated in Fig. 6(b). Fig. 6(b) is the plan view. In the multi-functional vibration actuator of Fig. 6, a magnetic circuit comprising a yoke 1', a permanent magnet 2', and a plate 3' is flexibly supported by a suspension 4' comprising an arc-shaped helical leaf spring fixed to a vibration transmitting portion 8', as illustrated in Fig. 6 by way of example. The suspension 4' is fixed to an outer peripheral portion of the yoke 1' of the magnetic circuit and the vibration transmitting portion 8'.

[0003]

The multi-functional vibration actuator comprises a vibrator member 5' and a coil 6' which is fixedly attached by an adhesive or the like to a vibrator recessed portion 16' formed in a radial direction of the vibrator member and which is arranged in a gap of the magnetic circuit. The vibrator member 5' is fixed to the vibration transmitting portion 8', like the suspension 4'. When the coil 6' is supplied with a driving current, the magnetic circuit or the coil 6' moves up and down in an axial direction. The vibration transmitting portion 8' serves as a fixed portion at a low frequency and, at a high frequency, serves as an elastic body to vibrate as a part of the vibrator member 5'. Thus, in each of a vibration mode and a sound mode, the magnetic circuit and the vibrator member 5' are operated under mutual interference to transmit a vibration to the

outside.

[0004]

In this event, the vibration transmitting portion 8' is provided with a protective cover B10' fixed thereto to protect a functional body. The protective cover B10' has a hole 11' having a large diameter. Herein, a center shaft 7' is inserted into a center hole of the magnetic circuit to penetrate therethrough.

[0005]

[Problem to be Solved by the Invention]

In the structure of the conventional multi-functional vibration actuator, the protective cover provided with the hole having the large diameter is used. Therefore, the vibrator member performs an unstable operation around a resonance frequency (f_o). This results in generation of a large harmonic distortion component.

[0006]

In addition, since the coil is fixedly attached to the vibrator member by the adhesive or the like, positioning of the coil is difficult and requires a long time even if an attaching jig is used. Furthermore, since the coil and the vibrator member are fixed to each other through a single surface having a small contact area, the coil may be released from the vibrator member due to an external factor such as a shock of a fall. Thus, a shock resistance is low.

[0007]

It is therefore an object of this invention to provide a multi-functional vibration actuator which is capable of suppressing an unstable operation of a vibrator member around a resonance frequency to reduce a harmonic distortion component by providing a cover fixed to a vibration transmitting portion with a single sound release hole or a plurality of sound release holes having a desired diameter for air viscosity attenuation. It is another object of this invention to provide a multi-functional vibration actuator which is capable of preventing a coil

from being released from a vibrator member by increasing the number of contact surfaces, from a single surface to a plurality of surfaces, through which the vibrator member is kept in contact with the coil fixedly attached by an adhesive or the like.

[0008]

[Means to Solve the Problem]

In order to solve the above-mentioned problems, a multi-functional vibration actuator according to this invention has a structure in which a cover fixed to a vibration transmitting portion is provided with one or a plurality of sound release holes having a desired diameter for air viscosity attenuation so that, when a driving current is applied, an unstable operation of a vibrator member around a resonance frequency (f_0) is suppressed to carry out an operation in a stationary state, thereby reducing a harmonic distortion component. Herein, in the multi-functional vibration actuator, the sound release hole has a shape of a circle, an ellipse, an elongated circle, a polygon, or a combination thereof.

[0009]

The multi-functional vibration actuator has an L-shaped or a U-shaped coil attaching portion formed at a desired position of the vibrator member in a radial direction thereof to increase the number of contact surfaces, from a single surface to a plurality of surfaces, through which the vibrator member is kept in contact with the coil fixedly attached by an adhesive or the like.

[0010]

Herein, the vibrator member is desirably made of at least one kind of plastic film material selected from polyether imide (PEI), polyester (PET), polycarbonate (PC), polyphenylenesulfide (PPS), polyarylate (PAR), polyimide (PI), and aramide (PPTA).

[0011]

Specifically, this invention provides a multi-functional vibration actuator including a magnetic circuit, a coil arranged in a gap of the magnetic circuit, and a suspension comprising an arc-shaped helical leaf spring fixed to a vibration transmitting portion and flexibly supporting the magnetic circuit, wherein the vibration transmitting portion is provided with a cover fixed thereto and having a sound release hole of a desired diameter for air viscosity attenuation.

[0012]

This invention also provides the multi-functional vibration actuator wherein the sound release hole is formed as a single hole or a plurality of holes located at desired position or positions of the cover.

[0013]

This invention also provides the multi-functional vibration actuator wherein the sound release hole has a shape of a circle, an ellipse, an elongated circle, a polygon, or a combination thereof.

[0014]

This invention also provides the multi-functional vibration actuator wherein the coil is fixedly attached to an L-shaped or a U-shaped attaching portion formed at a desired position of the vibrator member in a radial direction.

[0015]

This invention also provides the multi-functional vibration actuator wherein the vibrator member has a flat shape, a saucer shape, a curved shape, a corrugated shape, or a combination thereof.

[0016]

This invention also provides the multi-functional vibration actuator wherein the vibrator member is made of at least one kind of plastic film material selected from polyether imide (PEI), polyester (PET), polycarbonate (PC),

polyphenylenesulfide (PPS), polyarylate (PAR), polyimide (PI), and aramide (PPTA).

[0017]

[Embodiment]

Description will now be made about multi-functional vibration actuators according to embodiments of this invention with reference to the drawing.

[0018]

(Embodiment 1)

Fig. 1 is a view for describing ma ulti-functional vibration actuator according to a first embodiment of this invention. Fig. 1(a) is a sectional view taken along a line A-A in a plan view illustrated in Fig. 1(b). Fig. 1(b) is the plan view.

[0019]

The multi-functional vibration actuator illustrated in Fig. 1 is the embodiment of this invention and is shown in a sectional view and a partially cutaway view. A magnetic circuit has an inner magnet structure and is formed by a yoke 1 and a plate 3 with a disk-shaped permanent magnet 2 interposed therebetween. A center shaft 7 of a bolt-like shape or a pin-like shape is inserted and fitted into a center hole of the magnetic circuit to coaxially position the yoke 1, the permanent magnet 2, and the plate 3.

[0020]

The center shaft 7 may be removed after the yoke 1, the permanent magnet 2, and the plate 3 are coaxially positioned. These components of the magnetic circuit are fixed under attraction force of the permanent magnet 2 or by a combination of the attraction force and an adhesive. A suspension 4 comprises a single arc-shaped helical leaf spring, flexibly supports the magnetic circuit, and is fixed to an outer peripheral portion of the yoke 1 by the use of an

elastic material 18, such as a tackiness agent, an adhesive, or a resin or by means of caulking or the like with the other end fixed to a vibration transmitting portion 8. On the other hand, a coil 6 is fixedly attached by an adhesive or the like to a surface of an L shape 20 formed at a desired position of a vibrator member 5 and is disposed in a gap of the magnetic circuit.

[0021]

Since the vibrator member 5 with the coil 6 fixedly attached thereto has the L shape, the coil 6 is kept in contact with the vibrator member 5 not through a single surface but through two surfaces. Thus, the coil 6 is hardly released.

[0022]

Herein, a coil wire 19 is adhered to the surface of the vibrator member 5 by an adhesive or a tackiness agent so as to avoid an adverse influence upon vibration of the vibrator member 5. Furthermore, the coil wire is connected by a solder 15 to a terminal 14 of a terminal support 13 formed on an outer peripheral portion of the vibration transmitting portion 8 and is covered with a protector 17 for protecting the coil wire 19 and a connecting portion. The vibration transmitting portion 8 is provided with a protective cover A9 and a cover 24 fixed thereto to protect a functional body for producing the vibration and to exhibit an air-viscosity attenuating function, respectively.

[0023]

The suspension 4 is fixed to the outer peripheral portion of the yoke 1 to suppress shaking of the magnetic circuit. In order to prevent the magnetic circuit from being brought into contact with the vibrator member 5 due to an excessive amplitude upon occurrence of a shock of a fall or the like, the vibration transmitting portion 8 is provided with a stopper 12 formed on its inner peripheral surface. Herein, the stopper 12 may be formed as one piece or a plurality of pieces, or may be formed throughout the inner peripheral surface.

[0024]

It is noted here that the magnetic circuit may have an outer magnet type structure or a radial structure, instead of the inner magnet structure illustrated in Fig. 1. The yoke 1 of the magnetic circuit is formed into a shape such as a protrusion or a non-flat shape having a protrusion and a recess so as to facilitate generation of a high magnetic flux density in both of the inner magnet type and the outer magnet type. A magnetic pole of the permanent magnet 2 may be oriented in any direction. The suspension 4 is integrally connected to the vibration transmitting portion 8 by insert molding, welding, adhesion, or the like.

[0025]

The vibrator member 5 has a desired thickness and has a flat shape, a saucer shape, a curved shape, a corrugated shape, or a combination thereof. In case of the curved shape, a single radius of curvature or a combination of different radii of curvature is selected to achieve a predetermined sound characteristic. By increasing the rigidity of the vibrator member 5 inside the coil 6, a harmonic distortion in a high-frequency region can be reduced.

[0026]

The vibrator member 5 is made of polyether imide (PEI). The vibrator member can be similarly made of another plastic film material such as polyester (PET), polycarbonate (PC), polyphenylenesulfide (PPS), polyarlate (PAR), polyimide (PI), and aramide (PPTA).

[0027]

The outer peripheral portion of the vibrator member 5 is fixed to the vibration transmitting portion 8, if necessary, through an elastic material such as a tackiness agent, an adhesive, or a resin so as to obtain a greater amplitude of the vibrator member 5. The vibration transmitting portion 8 is formed by a resin or the like exhibiting an elasticity.

[0028]

The cover 24 fixed to the vibration transmitting portion 8 has one or a plurality of sound release holes of a desired diameter for air viscosity attenuation. The sound release hole has a shape of a circle, an ellipse, an elongated circle, a polygon, or a combination thereof. Furthermore, it is necessary to inhibit the air from flowing inward or outward except through the sound release hole for air viscosity attenuation.

[0029]

When the coil 6 is supplied with a driving current, the magnetic circuit flexibly supported by the vibrator member 5 and the suspension 4 fixed to the vibration transmitting portion 8 vibrates. At this time, the vibration transmitting portion 8 serves as a fixed portion at a low frequency and, at a high frequency, acts as an elastic body to vibrate as a part of the vibrator member 5. Thus, in each of a vibration mode and a sound mode, the magnetic circuit and the vibrator member 5 are operated under mutual interference.

[0030]

Fig. 2 shows a shape of the cover according to the embodiment of this invention. The cover 24 has an outer diameter of ϕ 17 mm and is provided with five sound release holes $21a_1$, $21a_2$, $21a_3$, $21a_4$, $21a_5$ (the total area being equal to about 3 to 8 mm^2) formed at desired positions of the cover 24 so as to exhibit the air viscosity attenuating function. The number of the sound release holes 21 formed in the cover 24 is not particularly limited. As regards outer dimensions of the multi-functional vibration actuator of this invention as a whole, the outer diameter is equal to ϕ 17 mm which is substantially equivalent to that of the cover 24 and the thickness t is equal to 4 mm. Fig. 3 shows the sound characteristic in the above-mentioned case.

[0031]

A thick solid line and a thick broken line represent characteristics of a

fundamental wave and a harmonic distortion, respectively, in case where the cover 24 of this invention illustrated in Fig. 2 is used. On the other hand, for comparison, a dash-and-dot line and a dotted line represent characteristics of a fundamental wave and a harmonic distortion, respectively, in case where a conventional protective cover B10 is used.

[0032]

In case where the conventional protective cover B10 having a large hole is used, a desired sound pressure level is satisfied. However, the harmonic distortion of a large magnitude is produced due to an unstable nonlinear operation of the vibrator member 5 around a resonance frequency (f_0). By using the cover 24 of this invention shown in Fig. 2, it is possible to suppress the unstable nonlinear operation of the vibrator member 5 around the resonance frequency (f_0) without decreasing the sound pressure level in a used frequency band so that the harmonic distortion component is reduced. In addition, it is possible to flatten the characteristic in a low frequency region.

[0033]

(Embodiment 2)

Fig. 4 is a sectional view of a multi-functional vibration actuator according to a second embodiment of this invention. The multi-functional vibration actuator illustrated in Fig. 4 has an L shape 22 which is reverse to the L shape 20 of the vibrator member 5 of Fig. 1 with respect the central shaft 7.

[0034]

(Embodiment 3)

Fig. 5 is a sectional view of a multi-functional vibration actuator according to a third embodiment of this invention. In the multi-functional vibration actuator illustrated in Fig. 5, the L shape 20 of the vibrator member 5 of Fig. 1 is replaced by a U shape 23. With this structure, the coil 6 is kept in contact with the vibrator member 5 not through two surfaces but through three

surfaces. Therefore, the coil 6 is hardly released from the vibrator member 5 as compared with the L shape illustrated in Fig. 1 or 4. Thus, this structure is highly reliable.

[0035]

[Effect of the Invention]

As described above, according to this invention, it is possible to provide the multi-functional vibration actuator having a structure in which the cover fixed to the vibration transmitting portion is provided with one or a plurality of sound release holes having a desired diameter for air viscosity attenuation so that, upon supply of the driving current, the unstable nonlinear operation of the vibrator member is suppressed to reduce the harmonic distortion component around the resonance frequency (f_0).

[0036]

In addition, the vibrator member has the L-shaped or the U-shaped coil attaching portion formed at the desired position in the radial direction so that the coil fixedly attached by an adhesive or the like is kept in contact with the vibrator member through an increased number of surfaces, i.e., increased from one surface to a plurality of surfaces. Thus, it is possible to provide the multi-functional vibration actuator which is capable of preventing the coil from being released from the vibrator member.

[Brief Description of the Drawing]

[Fig. 1]

A view for describing a multi-functional vibration actuator according to a first embodiment of this invention. Fig. 1(a) is a sectional view taken along a line A-A in a plan view illustrated in Fig. 1(b). Fig. 1(b) is the plan view.

[Fig. 2]

A top plan view showing a cover of the multi-functional vibration actuator according to the first embodiment of this invention.

[Fig. 3]

A view showing a sound pressure level versus frequency characteristic of the multi-functional vibration actuator according to the first embodiment of this invention.

[Fig. 4]

A sectional view of a multi-functional vibration actuator according to a second embodiment of this invention.

[Fig. 5]

A sectional view of a multi-functional vibration actuator according to a third embodiment of this invention.

[Fig. 6]

A view for describing a conventional multi-functional vibration actuator. Fig. 6(a) is a sectional view taken along a line B-B in a plan view illustrated in Fig. 6(b). Fig. 6(b) is the plan view.

[Description of the Reference Numerals]

1, 1' yoke
2, 2' permanent magnet
3, 3' plate
4, 4' suspension
5, 5' vibrator member
6, 6' coil
7, 7' center shaft
8, 8' vibration transmitting portion
9, 9' protective cover A
10' protective cover B
11' hole
12, 12' stopper
13, 13' terminal support

14, 14' terminal

15, 15' solder

16' vibrator recessed portion

17, 17' protector

18, 18' elastic material

19, 19' coil wire

20 L shape

$21a_1$, $21a_2$, $21a_3$, $21a_4$, $21a_5$ sound release hole (for air viscosity attenuation)

22 L shape (shape reverse to 20)

23 U shape

24 cover

[Name of Document] ABSTRACT

[Abstract]

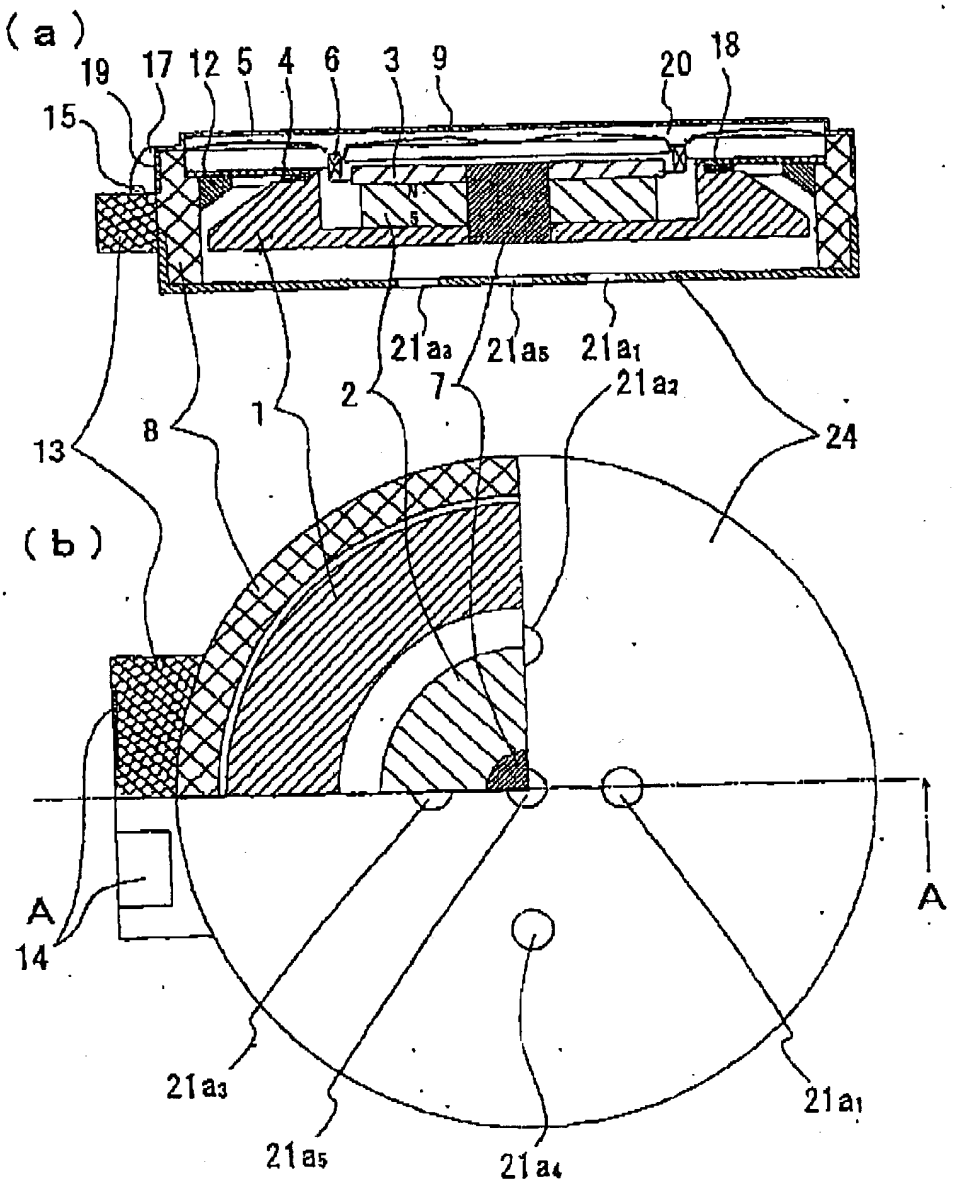
[Object] To provide a multi-functional vibration actuator which is capable of suppressing an unstable operation of a vibrator member around a resonance frequency to reduce a harmonic distortion component and which is capable of preventing a coil from being released from the vibrator member.

[Solution] In a multi-functional vibration actuator including a magnetic circuit, a coil 6 arranged in a gap of the magnetic circuit, and a suspension 4 comprising an arc-shaped helical leaf spring fixed to a vibration transmitting portion 8 and flexibly supporting the magnetic circuit, the vibration transmitting portion 8 is provided with a cover 24 fixed thereto and having sound release holes $21a_1$, $21a_2$, $21a_3$, $21a_4$, and $21a_5$ of a desired diameter for air viscosity attenuation.

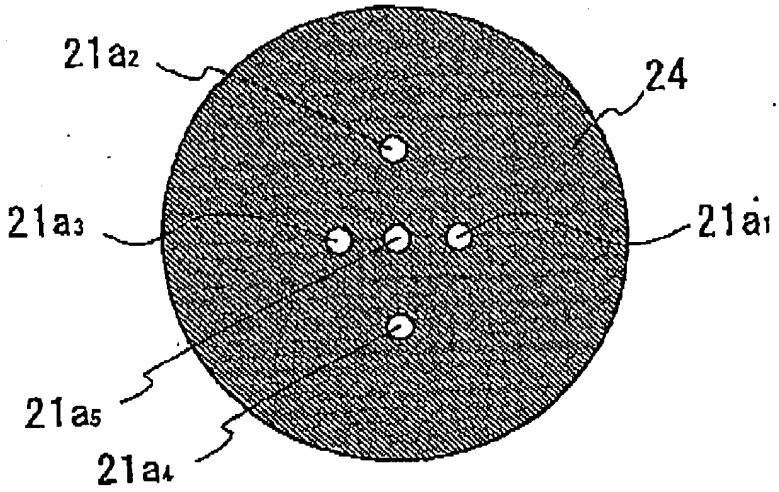
[Selected Figure] Fig. 1

(Name of Document) DRAWING

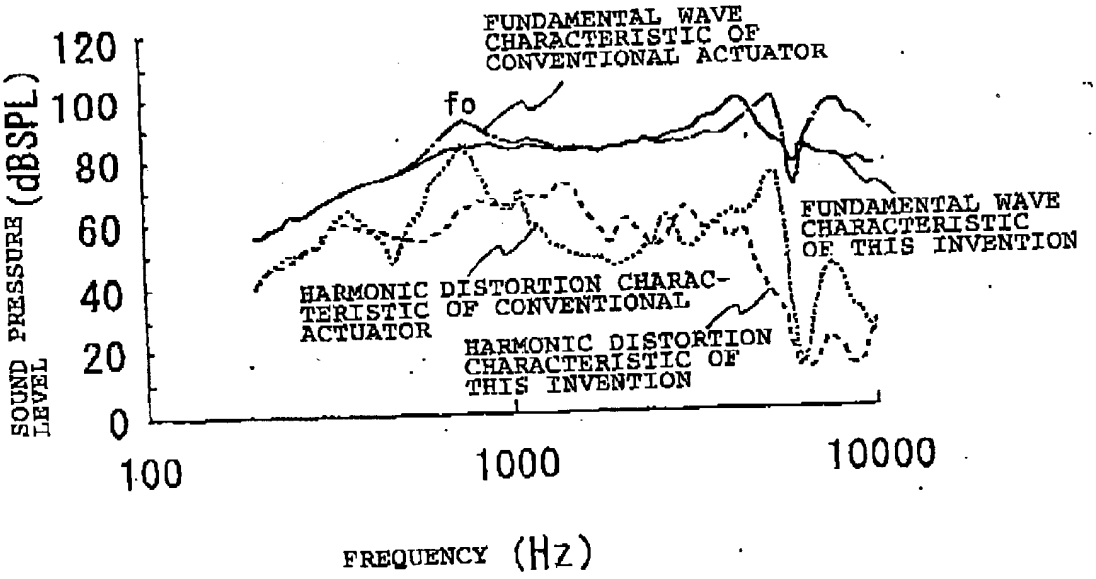
(Fig. 1)



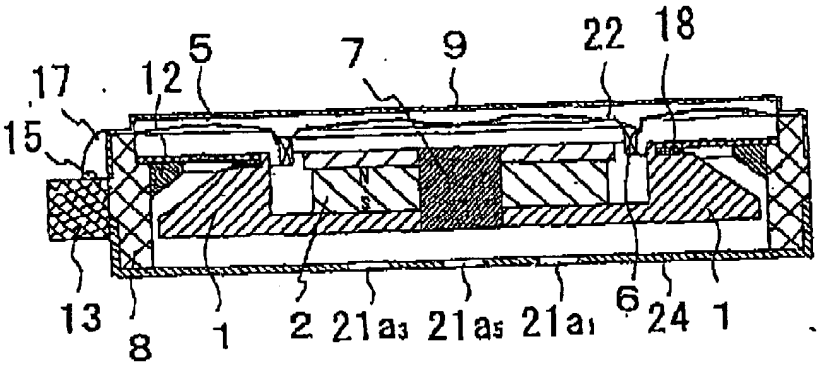
(Fig. 2)


21a2
24
21a3
21a1
21a5
21a4

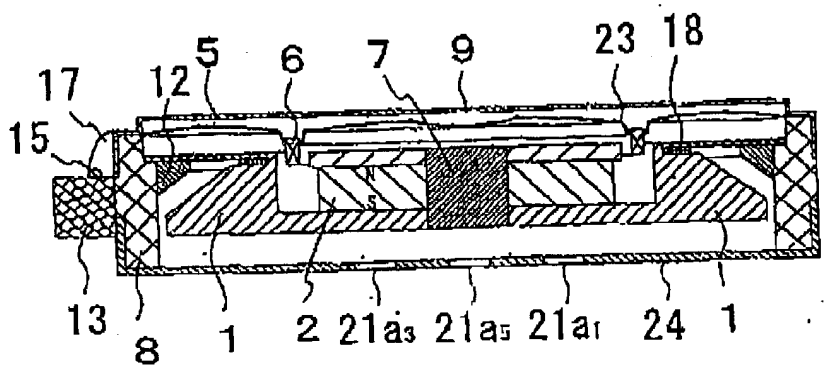
(Fig. 3)


FUNDAMENTAL WAVE CHARACTERISTIC OF CONVENTIONAL ACTUATOR
fo
FUNDAMENTAL WAVE CHARACTERISTIC OF THIS INVENTION
HARMONIC DISTORTION CHARACTERISTIC OF CONVENTIONAL ACTUATOR
HARMONIC DISTORTION CHARACTERISTIC OF THIS INVENTION
SOUND PRESSURE LEVEL (dBSPL)
120
100
80
60
40
20
0
100
1000
10000
FREQUENCY (Hz)

(Fig. 4)


17
12
5
7
9
22
18
15
13
8
1
2
21a3
21a5
21a1
6
24
1

(Fig. 5)


17
12
5
6
7
9
23
18
15
13
8
1
2
21a3
21a5
21a1
24
1

(Fig. 6)